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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

MERTON HOUSE
For Many Years the Home of William Bateson

"But Grantchester! ah, Grantchester!
There's peace and holy quiet there,
Great clouds along pacific skies,
And men and women with straight eyes."

DECEMBER, 1926 VOL. 17, No. 12

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The

Journal of Heredity

VOL. XVII, NO. 12 DECEMBER, 1926

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The JOURNAL OF HEREDITY is published monthly by the

AMERICAN GENETIC ASSOCIATION

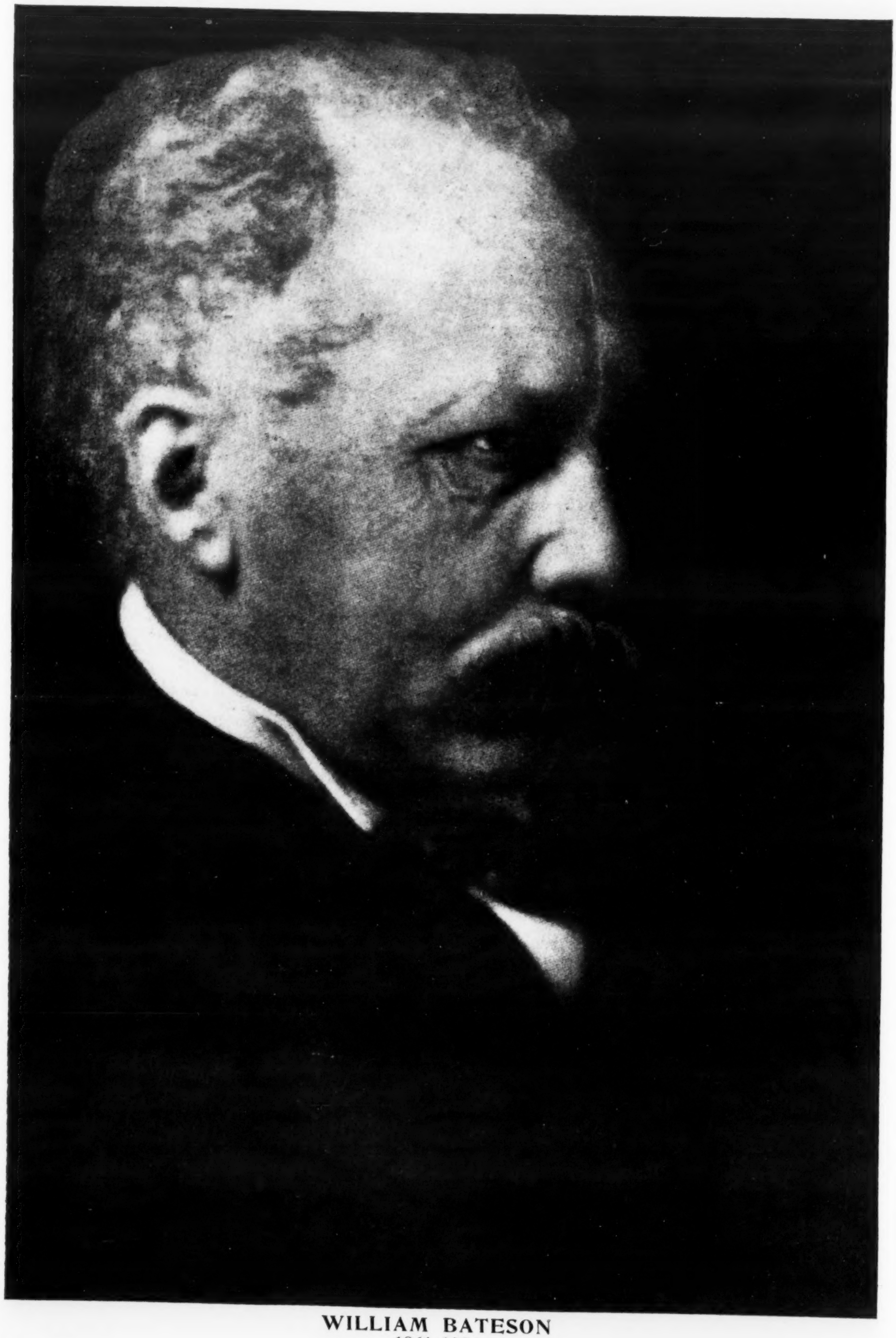
At 1918-32 Harford Avenue, Baltimore, Md., and
Victor Building, Washington, D. C.

Address communications regarding editorial matters and the business management of the Association to Room 306, Victor Building, Washington, D. C.

Entered as second class matter February 24, 1923, at the post office at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized December 20, 1918. Contents copyrighted 1927 by the American Genetic Association. Reproduction of articles or parts of articles permitted only upon request, for a proper purpose, and provided due credit is given to the author and to the JOURNAL OF HEREDITY, Washington, D. C.

Date of Issue of this number, February 12, 1927

$3.50 *a Year; 35c the Copy*



WILLIAM BATESON
1861-1926

"If the Proceedings of the Brunn Natural History Society had been a little more rare, Bateson's body would have been buried in Westminster Abbey, for we have only to read between the lines of the first report to the Evolution Committee of the Royal Society by himself and Miss E. R. Saunders (1902) to realize that when Mendel's paper was rediscovered in 1900, Bateson had already hit upon the atomic theory of heredity, which goes by the name of Mendelism."

WILLIAM BATESON, 1861-1926

His Life and Work

By A Fellow of the International Education Board*

IN the death of William Bateson, the pioneer and leader of the English geneticists, on February 8, 1926, the whole scientific world suffered an irreparable loss. Some years before the rediscovery of Mendelism in 1900, this world figure in biology had attained eminence as a student of variation and since that time he had been continuously and actively engaged in the study of the complex problems of heredity in animals and plants.

The writer had the privilege of attending a meeting of the Genetical Society in London at which Mr. Bateson presided only a few weeks before his death. In every new fact reported in this meeting, Mr. Bateson showed his characteristically keen interest, his usual vigorous manner, and an almost fatherly encouragement of the younger members of the society who presented papers or joined in the discussion.

William Bateson, the son of the Rev. W. H. Bateson, D.D., Master of St. Johns College, Cambridge, from 1857 to 1881, was born at Whitby in 1861. In 1896, he married Beatrice, daughter of the late Arthur Durham, Senior Surgeon of Guy's Hospital. His wife survives him, with one son, who is a member of St. John's College, Cambridge. Another son was lost in the war.

Education

Mr. Bateson attended Rugby School, and continued his education at St. John's College, Cambridge, where he gained a scholarship. He took first class honors in the Natural Science Tripos Examinations of 1882 and 1883. In the latter year he was elected to a fellowship and in 1910 was made an honorary fellow of St. John's College. Mr. Bateson held an M.A. degree from Cambridge University and an honorary Doctor of Science degree from Sheffield University.

Honors

The world's recognition of his scientific distinction was wide and real, yet some of the formal signs of recognition in his own country had not fallen to his lot when he died. On the Continent he was widely known and respected. He had hosts of scientific friends in France, Germany, Russia, and in other countries. As recently as the autumn of 1925 he attended the Russian Scientific Congress as an invited guest, and on several previous occasions he had visited the leading continental workers in biology, attended their meetings, and contributed to their programs. Mr. Bateson was a Fellow of the Royal Society, Foreign Member of the National Academy of

*The writer gladly takes this opportunity to thank the several members of the "Cambridge School" who aided him in gathering the material for this article. He also wishes to acknowledge his indebtedness to the Editors of the *London Times*, *The Manchester Guardian*, *Nature*, *The Nation and Athenaeum*, *Science*, *The Eagle* (of St. John's College, Cambridge), *The Cambridge Review*, *The Journal of Genetics* and *The Eugenics Review* for the use of material which appeared originally in these publications.

If this rather sketchy and incomplete review proves helpful to even a small number of fellow students in England, America, and other countries, who wish to learn more of the life and work of this great man, the writer will feel well repaid for the time spent in gathering and presenting this material. He has in fact already been handsomely rewarded in the inspiration and fresh enthusiasm imparted to him through contact with some of Mr. Bateson's former Cambridge colleagues, through his visit to the quiet and delightful Merton House at Grantchester, and in reading and re-reading some of Mr. Bateson's own writings.

Sciences in Washington, Member of the New York Academy of Science, Member of the Royal Danish Academy, the Royal Academy of Belgium, Academy of Sciences of Leningrad, and of several other scientific societies. He received the Darwin Medal of the Royal Society in 1904 and the Royal Medal in 1920. He was a charter member of the American Genetic Association.

He was Fullerian Professor of Physiology of the Royal Institution in 1912-1914, President of the British Association at the Austrialia Meeting in 1914, and was to have attended the Canadian Educational Conference in April, 1926. He had been elected President of the Botanical Section of the British Association for the Oxford Meeting in August, 1926.

In 1907 Mr. Bateson gave the Silliman Lectures at Yale University, and in 1922 he delivered the Joseph Leidy Memorial Lecture at the University of Pennsylvania. On the same trip he addressed the Toronto meeting of the American Association for the Advancement of Science.

Mr. Bateson was a member of the Athenaeum and of the Burlington Fine Arts Club.

The Years at Cambridge

One cannot escape the feeling that the years spent at Cambridge were at once the richest, most productive, and perhaps the happiest period in the life of William Bateson. Several close friends and former associates of this distinguished member of the University have given the writer the most cordial help in his effort to describe some of the features of this period, but only those who were members of the early "Cambridge School" of heredity can fully appreciate the influence of their leader, Mr. Bateson, not only on their own work and scientific careers but on the thought of biological workers throughout the world. As one of this Cambridge group has put it, Mr. Bateson was "one of that very small band of great teachers whose members have seen their earlier heterodoxy accepted as the orthodoxy of the younger generation."

Mr. Bateson's first efforts in research were in the field of comparative embryology. As experimental material he chose the worm-like *Balanoglossus*, an organism whose position in the phylogenetic scheme was then uncertain. Mr. Bateson visited America to obtain material for these studies in 1883, and again in 1884. An important outcome of these visits to America was the meeting with W. K. Brooks, who had a great influence on the direction of his thoughts.

His morphological studies of *Balanoglossus,* which definitely fixed the evolutionary or taxonomic position of this organism, focused his attention on the age-old problem of the nature of species, which gripped and held him for the rest of his life.

In 1897-1898, while the Batesons occupied Norwich House, Cambridge, breeding experiments were in progress in the nearby University Botanical Garden with Lychnis and with fowls. In 1897, Mr. Bateson had read of some of deVries' early experiments on heredity, and had sent to the Dutch botanist, who was later to be the author of the mutation theory, for some seeds.

Bateson had satisfied himself as to the existence of discontinuity in variation, and in the closing years of the last century had begun experiments in crossing, which were to reveal to him the same laws, earlier discovered by Mendel, and rediscovered in 1900 by deVries, Correns, and Tschermak. In fact, Haldane* goes so far as to say that if the Proceedings of the Brünn Natural History Society had been a little more rare, Bateson's body would have been buried in Westminster Abbey, for we have only to read between the lines of the first report to the Evolution Committee of the Royal Society by himself and Miss E. R. Saunders

*William Bateson, by J. B. S. Haldane, in *The Nation and Athenaeum.* February 20, 1926.

MERTON HOUSE

In the little village of Grantchester near Cambridge—the home of William Bateson from 1899 to 1910. In the garden of Merton House many of his early experiments in Genetics were carried on, and here the word seems to have been born, as Bateson first used it in a paper published in 1906.

(1902) to realize that when Mendel's paper was rediscovered in 1900, Bateson had already hit upon the atomic theory of heredity, which goes by the name of Mendelism.

The aims underlying this early work and the hopes entertained of it, are set forth in an address to the Hybrid Conference held in London during July, 1899.* Noteworthy is the stress laid upon the necessity of examining hybrid progeny *statistically*, and of classifying the offspring in respect to each differentiating character, *separately*.

In making reference to these early reports, Morgan† says, "One feature of these reports is characteristic. Nothing is glossed over for the sake of uniformity. Exceptions are reported and emphasized. Their examination whenever possible is the starting point for further study that is often illuminating."

In the words of a Cambridge friend of the Batesons‡ "There are many in Cambridge, who, while making no claim to scientific interest, have looked forward to an afternoon pilgrimage to the house out at Grantchester, where there was always something new to be seen, whether chickens or primulas, old drawings or Japanese prints, all shown with an enthusiasm and freshness of comment very stimulating to the listener."

The charm of Merton House at Grantchester is maintained by the pres-

*Obituary Notice in *Nature*, February 27, 1926.
†Morgan, T. H. *Science*, May 28, 1926.
‡*Cambridge Review*, November 25, 1909.

ent owners. The writer was more than a little interested to see the garden where "coupling" and "repulsion" in sweet peas were first observed, the ground where the inheritance of "rose," "pea," "walnut" and other forms of combs in fowls was first worked out, and the study where the book *Mendel's Principles of Heredity* and many of the earlier papers were put in writing.

To the Cambridge period belong also the formulation of the "presence and absence" theory (which Bateson again champions in his last paper) the solution of the old problem of "reversion" on crossing, the demonstration of the nature of sex-linked inheritance, and much other original work of the first importance. During these years, this garden at Grantchester was the world center for genetical work and thought, attracting visitors from many lands. Indeed, it is true, in one sense at least that "genetics" was born at Grantchester near Cambridge, for apparently it was Bateson who first used this term in a paper written there in 1906.

In 1899 the Batesons moved to Merton House, in the little village of Grantchester, near Cambridge. Perhaps our portrait of this fine home and garden and the young poet's description of this lovely spot will give the reader some idea of the surroundings in which Bateson spent ten of his most fruitful years:

The Old Vicarage, Grantchester

(Cafe des Westens, Berlin, May, 1912)

JUST now the lilac is in bloom,
All before my little little room;
And in my flower-beds, I think
Smile the carnation and the pink;
And down the borders, well I know,
The poppy and the pansy blow. . . .
Oh! there the chestnuts, summer through,
Beside the river make for you
A tunnel of green gloom, and sleep
Deeply above; and green and deep
The stream mysterious glides beneath
Green as a dream and deep as death.
- - Oh, damn! I know it! and I know
How the May fields all golden show
And when the day is young and sweet,
Gild gloriously the bare feet
That run to bathe . . . Du lieber Gott!
Here am I, sweating, sick, and hot,
And there the shadowed waters fresh
Lean up to embrace the naked flesh,
Temperamentvoll German Jews
Drink beer around; - - and there the dews
Are soft beneath a morn of gold.
Here tulips bloom as they are told;
Unkempt about those hedges blows
An English unofficial rose;
And there the unregulated sun
Slopes down to rest when day is done
And wakes a vague unpunctual star,
A slippered Hesper; and there are
Meads towards Haslingfield and Coton
Where das Betreten's not Verboten.

. . . . . would I were
In Grantchester, in Grantchester! -
Some, it may be, can get in touch
With Nature there, or Earth, or such
And clever modern men have seen
A Faun a-peeping through the green,
And felt the classics were not dead;
To glimpse a Naiad's reedy head,
Or hear the Goat-foot piping low . .
But these are things I do not know.
I only know that you may lie
Day long and watch the Cambridge sky,
And, flower-lulled in sleepy grass,
Hear the cool lapse of hours pass,
Until the centuries blend and blur,
In Grantchester, in Grantchester . .
Still in the dawnlit waters cool
His ghostly Lordship swims his pool,
And tries the strokes, essays the tricks
Long learnt on Hellspont, or Styx.
Dan Chaucer hears his river still
Chatter beneath a phantom mill.
Tennyson notes, with studious eye,
How Cambridge waters hurry by . . .
And in that garden, black and white,
Creep whispers through the grass all night;
And spectral dance, before the dawn,
A hundred Vicars down the lawn;
Curates, long dust, will come and go
On lissom, clerical, printless toe;
And oft between the boughs is seen
The sly shade of a Rural Dean . . .
Till, at a shiver in the skies,
Vanishing with Satanic cries,
The prim ecclesiastic rout
Leaves but a startled sleeper-out,
Grey heavens, the first bird's drowsy calls,
The falling house that never falls.
God! I will pack, and take a train,
And get me to England once again!
For England's the one land, I know
Where men with Splendid Hearts may go;
And Cambridgeshire, of all England,
The shire for Men who Understand;
And of that district I prefer
The lovely hamlet Grantchester.
For Cambridge people rarely smile,
Being urban, squat, and packed with guile;
And Royston men in the far South
Are black and fierce and strange of mouth;
At Over they fling oaths at one,
And worse than oaths at Trumpington,
And Ditton girls are mean and dirty;
And there's none in Harston under thirty,
And folks in Shelford and those parts

Have twisted lips and twisted hearts,
And Barton men make Cockney rhymes,
And Coton's full of nameless crimes,
And things are done you'd not believe,
At Madingley on Christmas Eve.
Strong men have run for miles and miles,
When one from Cherry Hinton smiles;
Strong men have blanched, and shot their wives,
Rather than send them to St. Ives;
Strong men have cried like babes, bydam,
To hear what happened at Babraham,
But Grantchester! ah, Grantchester!
There's peace and holy quiet there,
Great clouds along pacific skies,
And men and women with straight eyes,
Lithe children lovelier than a dream,
A bosky wood, a slumberous stream,
And little kindly winds that creep
Round twilight corners, half asleep. I.I.
In Grantchester their skins are white;
They bathe by day, they bathe by night;
The women there do all they ought;
The men observe the Rules of Thought.
They love the Good; they worship Truth;
They laugh uproariously in youth;
(And when they get to feeling old,
They up and shoot themselves, I'm told) . .
Ah God! to see the branches stir
Across the moon at Grantchester!
To smell the thrilling-sweet and rotten
Unforgettable, unforgotten
River-smell, and hear the breeze
Sobbing in the little trees.
Say, do the elm-clumps greatly stand
Still guardians of that holy land?
The chestnuts shade, in reverend dream,
The yet unacademic stream?
Is dawn a secret, shy and cold
Anadyomene, silver-gold?
And sunset still a golden sea
From Haslingfield to Madingley?
And after, ere the night is born,
Do hares come out about the corn?
Oh, is the water sweet and cool,
Gentle and brown, above the pool?
And laughs the immortal river still
Under the mill, under the mill?
Say, is there Beauty yet to find?
And Certainty? and Quiet kind?
Deep meadows yet, for to forget
The lies, and truths, and pain? . . . oh! yet
Stands the Church clock at ten to three?
And is there honey still for tea?

Rupert Brooke.

Early Cambridge Associates of Mr. Bateson

IT is impossible to name and mention the work of all the members of the small but faithful and loyal band of workers who were associated with Mr. Bateson, in the earlier years at Cambridge. He valued their help very highly, and in his book *Mendel's Principles of Heredity,* published in 1909, he gives generous acknowledgment to his colleagues when he says "Without their cooperation there would have been, so far as Cambridge is concerned, but meagre contributions to record." Miss E. R. Saunders of Newnham College, Cambridge, was very early associated with Mr. Bateson, was joint author with him of several of the now historical "Reports to the Evolution Committee of the Royal Society." Miss Saunders did some of the early genetical work in sweet peas, and in later years has carried out a masterful genetic analysis of the common stock, Mathiola.

Dr. C. C. Hurst, himself a pioneer Mendelian, was an early associate of Mr. Bateson, furnished experimental materials from his private nursery and estate, and was joint author of the 1905 Report to the Evolution Committee.

Miss Muriel Wheldale (now the Honorable Mrs. Onslow) was associated with Mr. Bateson in the early and thorough studies of the chemical basis and mode of inheritance of some of the anthocyanin and other pigments in plants. These studies have probably come as near to serving as a *liason* between the sciences of chemistry and genetics as any that have ever been made, at least on the plant side. They may well serve as the classics, from which modern bio-chemical and genetic research can proceed further with the difficult task of tracing the connection between observed or outer effect and inner cause.

Prof. R. C. Punnett was for many years the close colleague of Mr. Bateson, was joint author with him of many papers, assisted him in many of the early researches, especially those with sweet peas and the linkage studies, and succeeded him when he left Cambridge, in 1910.

In plant breeding, Prof. Sir Rowland Biffen has established an international reputation for himself and for Cambridge, as a result of his long continued, careful, and sucessful work in wheat breeding and improvement. He and Mr. Bateson were associated as members of the University in the early years and until Mr. Bateson left in 1910, though the work of Professor Biffen is largely economic, and is carried on in the School of Agriculture, while Mr. Bateson's interests were entirely in the field of theoretical or "pure science" genetics.

Mr. L. Doncaster, a former member of the Zoology Department in Cambridge University did a great amount of early cytological work and also studied the inheritance of sex and other characters in moths.

Mr. R. P. Gregory carried on, with Mr. Bateson, many of the early and illuminative genetic experiments with Primulas. Miss Florence M. Durham, (Mrs. Bateson's sister) carried on inheritance studies with mice.

Mr. Bateson Leaves Cambridge

THE great decision, in his scientific career, that Bateson was called upon to make, was in 1910, when he was invited to become Director of the John Innes Horticultural Institution at Merton. It did not then look as if Cambridge would provide him with endowment and facilities for pressing forward his genetical work, and so he decided, on scientific considerations, that he must accept the offer. The great work that he started there is briefly mentioned in a later paragraph. It may here be remarked, that Bateson probably did not foresee the loss of easy contact with his colleagues and with successive generations of young enthusiasts, that the move from Cambridge would entail. The loss which

Cambridge science and Cambridge life suffered with the departure of his dominating figure was only too clearly foreseen, with deep regret, by all his friends in the University.

It may not be out of place here, to set down a few quotations from some of the farewell paragraphs which appeared in Cambridge journals at the time Mr. Bateson left, in 1910. The photograph which accompanies this article was taken about a year before this turning point in his career, and was published in *The Gownsman* on December 8, 1909.

One of Mr. Bateson's friends had this to say: "His freedom from the trammels of conventional thought, his power of putting things in a new light, is a delightful stimulus to those whose brains work in more conventional channels. Enthusiasm, honesty, modesty were part and parcel of this great man. He was never afraid to confess his ignorance, always willing and eager to learn from everyone. Thus he taught and inspired no less by precept than by example."

Another colleague wrote as follows: "Few have been more intimately associated with the life and work of Cambridge than Professor Bateson, and there is no one whose loss could make a greater gap. Outside England, no biologist is better known, and wherever the problems of heredity are studied, he is looked to not only as the founder and head of 'the Cambridge School,' but as the most inspiring figure in these new-old studies."

The Years at Merton

When Bateson went to Merton in 1910 there was nothing save a great opportunity, and he made magnificent use of it. Between 1910 and 1926 there grew up a splendidly equipped station for research in genetics, one of the finest of its kind in the world. The staff consists of an enthusiastic and devoted band of more than a dozen workers. Students from several foreign countries have spent longer or shorter periods of time at Merton, where they have greatly appreciated Mr. Bateson's encouragement, counsel, and helpful criticism. Of the seed which Bateson's leadership has sown at Merton, some fruits have been garnered, but the full harvest is yet to come.

The keynote of the researches at Merton has been segregation, its nature and the time of its occurrence. The striking series of investigations on variegation, bud-sports, root cuttings, and "rogues" in peas is familiar to students of heredity who are readers of the *Journal of Genetics*. His matured judgment on these phenomena appeared in the *Journal* in his last paper on Segregation, only a few days before his death.

According to Morgan* Bateson was attracted by these problems partly because they were puzzles, partly, no doubt, because they did not seem to conform to the then current methods of genetic analysis and might therefore open up new fields of adventure.

Cytological studies have been emphasized in the work at Merton in recent years. Physiological studies under the leadership of Professor Priestley of Leeds University have also been made. Mycologic studies of silver leaf disease have been made by Mr. F. T. Brooks of the Cambridge Botany School.

The Biometrical Controversy

Lack of space precludes a detailed account of the strife between Mendelists, led by Bateson, and the Biometricians, headed by Karl Pearson and Weldon. Perhaps it is just as well not to try to re-enact for the readers of the present-day this bit of biological history. It need only be said that Weldon published a paper in *Biometrika* in January, 1902, minimizing the importance of Mendel's discovery. A few months later appeared the small but mighty volume by Bateson, entitled

Loc. Cit.

Mendel's Principles of Heredity: A Defence. In the preface to this little volume, Bateson says: "In the study of evolution, progress had well-nigh stopped, most were content supinely to rest on the great clearing Darwin made long since. It was therefore with a regret approaching to indignation that I read Professor Weldon's criticism."

Bateson agreed that biology must become an exact science, but held that "exactness is not always attainable by numerical precision; there have been students of Nature, untrained in statistical nicety, whose instinct for truth yet saved them from perverse influence, from slovenly argument, and from misuse of authorities, reiterated and grotesque." The opposing opinions of the two schools were expressed from time to time during the next two years, and at the Cambridge meeting of the British association in 1904 came the inevitable clash, when Bateson, as President of the Zoological Section, delivered a stirring challenge to the most crowded audience of the meeting. At the close of the debate which followed, in which Weldon remarked,—"It is better to use the purely descriptive statements of Galton and Pearson, than to involve the cumbrous and undemonstrable gametic mechanism on which Mendel's hypothesis rested," it was clear that Mendel had been fully vindicated.

In the words of Morgan.* "his vigorour onslaught (based on direct familiarity with the facts in the case) on Weldon's misleading review of Mendel's work, made it impossible that the importance of the new discovery should be overlooked or disregarded."

Bateson and the Chromosome Theory of Heredity

Haldane* records that for eight years Bateson attacked the chromosome theory with the utmost vigor, not because he considered it inherently improbable, but because he believed that it went beyond the evidence, and because the natural bent of his mind and his profound knowledge of the history of science led him to doubt the validity of long chains of reasoning, however convincing. When, however, the possibility of ocular demonstration arose, he visited America and returned to England a convert, though with certain reservations which Haldane believes the future will largely justify.

In a review of Baur's book written in 1911, Bateson expressed his views on the chromosome theory in the following words: "The only point in this excellent book which calls for criticism, is, in my judgment, the rather crude representation of segregation as effected by chromosomes. These pictures will live in the memory of the reader and tend to limit his imagination of the possibilities more closely than the known facts at present warrant."

In Mr. Bateson's last paper, which came out in the January (1926) number of the *Journal of Genetics*, only a few days before his death, he maintained to a considerable degree his well-known critical and conservative attitude toward some of the modern views on genetics emphasized in America, especially by the Morgan school. Whatever history shall record as to the details of the questions under discussion, it seems likely that Mr. Bateson's conservatism as to the general application of some of the hypotheses advanced by the *Drosophila* workers will prove of permanent value. It may serve to stimulate plant geneticists to conduct their own researches in such manner as to enable them to do more of their own thinking, fitting their interpretations to, and building their hypotheses on, genetic researches with plants. The closing paragraph of this last paper of Mr. Bateson's is here quoted:

> Having in view the various facts and considerations here enumerated I think we shall do genetical science no disservice if we postpone acceptance of the chromosome theory in its many extensions and implica-

Loc. cit.

tions. Let us distinguish fact from hypothesis. It has been proved that, especially in animals, certain transferable characters have a direct association with particular chromosomes. Though made in a restricted field this is a very extraordinary and most encouraging advance. Nevertheless the hope that it may be safely extended into a comprehensive theory of heredity seems to me ill-founded, and I can scarcely suppose that on a wide survey of genetical facts, especially those so commonly witnessed among plants, such an expectation would be entertained. For phenomena to which the simple chromosome theory is inapplicable, save by the invocation of a train of subordinate hypotheses, have been there met with continually, as even our brief experience of some fifteen years has abundantly demonstrated. Through all this work, with ever increasing certainty, the conviction has grown that the problem of heredity and variation is intimately connected with that of somatic differentiation, and that in an analysis of the interrelations of these two manifestations of cellular diversity lies the best prospect of success. Pending that analysis, the chromosome theory, though providing much that is certainly true and of immense value, has fallen short of the essential discovery.

Bateson Not Much Concerned with Practical Applications of Genetics

In his Presidential Address to Section D of the British Association, meeting at Cambridge in 1904, he said: "The question may occur to some members of this audience, 'Is this new knowledge of any use?' That is a question with which we, here, have fortunately no direct concern. Our business in life is to find things out, and we do not look beyond."

In another address, Bateson said, "Alliances between pure and applied science are as dangerous as those of spiders, in which the fertilizing partner is apt to be destroyed."

This attitude he carried with him to the end, for in none of his own work, or in that of his immediate associates or assistants, were the practical problems of the plant breeder, animal breeder, nurseryman, horticulturist, or farmer given direct or first attention.

Bateson Not in Sympathy with the Eugenics Movement

Although Mr. Bateson was tremendously interested in the problems of heredity as affecting the human race, he regarded most, if not all, the attempts to apply science to this problem by creating an art of eugenics as premature, in view of our profound ignorance of human heredity. He resolutely refused to associate himself with eugenical organizations.

As a biologist he could not accept current notions of "equality." Therefore he appeared as a champion of aristocracy, in short, a disbeliever in institutions and movements tending to hinder the d o m i n a n c e of superior breeds. He had a deep interest in the American population problem, which visits to the United States had made very real to him. One curious result of his studies was that he was disposed to regard democracy rather than socialism as the true enemy of national progress.

In one of his lectures Bateson pointed out in plain language what he regarded as "an appalling lack of conscious foresight in the preservation of the human race, and the effect of the modern tendency to preserve the socially unfit."

Bateson contended that a mixed population may better serve the purposes of modern civilization than a homogeneous one.

Speaking again of democracy, Bateson said, "The essential difference between the ideals of democracy and those which biological observation teaches us to be sound, is this: democracy regards class distinction as evil, we perceive it to be essential."

In the Galton Lecture, delivered before the Eugenics Education Society in 1921, Mr. Bateson expressed himself as follows:

> There are plenty of ways in which common sense might be applied to racial problems. That we shall see any such application in our own country seems to me in a high degree unlikely.
>
> Equality of political power has been bestowed on the lowest elements of our population. This is nearing the final stage of democratic decay, in which the lowest not only have the power, but exercise it, a sequel which the next generation may witness.

The following paragraph on sociological application is taken from his book, *Mendel's Principles of Heredity,* published in 1909:

> To the naturalist it is evident that while the elimination of the hopelessly unfit is a reasonable and prudent policy for society to adopt, any attempt to distinguish certain strains as superior and to give special encouragement to them would probably fail to accomplish the object proposed, and must certainly be unsafe.

The war was a terrible strain on Mr. Bateson. He had been in close personal relations with scientific colleagues in both France and Germany, and science was to him a higher intercourse that transcended nationality. The declaration of war was a real shock to the convictions of his intellect.

Bateson as a Writer

Bateson was a forceful writer and often poured out his single-minded wrath on his opponents in the biological controversies round the laws of heredity. His vigor was schooled into a fine literary form, bright with wit and happily turned phrases; he could write tenderly when he chose. He had an ability, as Morgan puts it,* to express himself fearlessly in classical and clear English.

Books

Between 1894 and 1913, four books came from Bateson's pen. The first and perhaps the greatest, of these, *Materials for the Study of Variation* (1894) marked an era in the development of biological thought.

The writer has thought it proper to include brief extracts from each of the four books, which will aid the reader in gaining some understanding of the mind of Bateson and of its grasp of the broad outlines of the problems of evolution and heredity as developed over a period of years.

The sub-title of *Materials for the Study of Variation* emphasized the special regard which the book paid to *discontinuity* in the origin of species. The book was offered as a contribution to the study of the problem of species. The few quotations which follow, must suffice. The interested reader of this article may well read or re-read the book itself:

> To collect and codify the facts of variation is the first duty of the naturalist.
>
> Whatever our views of Descent, Variation is the Common basis of them all.
>
> Variation is not studied for its own sake.
>
> So long as skilled zoologists continue to neglect all forms that are abnormal, the student of variation must turn to other sources.
>
> If the study of variation can serve no other end, it may make us remember that we are still at the beginning, that the complexity of the problem of specific difference is hardly less now than it was when Darwin first showed that natural history is a problem and no vain riddle.
>
> The naturalist must be content to work with the simplest cases, getting from them such truths as he can, learning to value partial truth though he cheat no one into mistaking it for absolute or universal truth; remembering the greatness of his calling, and taking heed that after him will come Time, that "author of authors," whose inseparable property it is ever more and more to discover the truth, who will not be deprived of his due.

This concluding paragraph of the preface to *Materials for the Study of Variation,* records Bateson's lofty conception of the calling of the naturalist. In the words of a close friend and associate in Cambridge, "By no man has this been more finely set forth; by none has it been more truly lived."

A few extracts from the "Concluding Reflections" of the *Materials for the Study of Variation* will perhaps aid the reader in seeing the problem of variation as Mr. Bateson saw it in 1894:

> The discontinuity of species results from the discontinuity of variation.
>
> The doctrine that the fixity of a character is a measure of its importance to the organism, is absurd.
>
> It is a "mischievous error" to suppose that a new variation must immediately be swamped.
>
> Among characters which blend, are especially certain quantitative characters, such as stature, while qualitative differences, as for example, color, are more often alternative

Loc. cit.

in their inheritance. The only way in which we may hope to get at the truth is by the organization of systematic experiments in breeding, a class of research that calls perhaps for more patience and more resources than any other form of biological inquiry. Sooner or later such investigation will be undertaken and then we shall begin to know.

We have collectors attending to the tangible business of classification, accounting themselves happy if they can keep their species apart, caring little how they become so, and rarely telling us how they may be brought together.

Bateson's concluding statement is as follows: "Of this one thing there is no doubt, that if the problem of species is to be solved at all, it must be by the study of variation."

In the second book written by Mr. Bateson, *Mendel's Principles of Heredity; A Defence,* published in 1902, there was first made generally available to the English reader, a translation of Mendel's original paper on Plant Hybrids. The Royal Horticultural Society had printed the first English translation a year earlier, for which Mr. Bateson wrote a brief introduction.

In the preface to this book, Bateson writes of Mendelian studies as follows: "The experimental study of heredity, pursued on the lines Mendel has made possible, is second to no branch of science in the certainty and magnitude of the results it offers."

In the concluding paragraph he says, "In these pages I have only touched the edge of that new country which is stretching out before us, whence in ten years time we shall look back on the present days of our captivity."

In the pioneer book, *Mendel's Principles of Heredity,* published in 1909, Bateson included an excellent and most interesting Biographical Note of Mendel, based in part on his own notes made during a visit to Brünn.

In the preface he says, "The study of heredity has become an organized branch of physiological science, already abundant in results, and in promise unsurpassed."

The book is, and has been, too well known by every serious student of Mendelism, to need further mention here.

Bateson's fourth and last book is entitled, *Problems of Genetics* (1913), and contains the Silliman lectures, delivered at Yale University. In the preface to this volume, Mr. Bateson thanks his friends in Yale for the high honor they did him in extending the invitation to lecture there, and for "much kindness received during a delightful sojourn in that genial home of learning."

The purpose of the lectures, he said, "is to discuss some of the wider problems of biology in the light of knowledge acquired by Mendelian methods of analysis."

He goes on to say, "That species have come into existence by an evolutionary process no one seriously doubts; but few who are familiar with the facts that genetic research has revealed, are now inclined to speculate as to the manner by which the process has been accomplished."

In the first chapter, on *The Problem of Species and Variety,* Mr. Bateson sharply criticizes the methods of systematists, in these words: "Systematists proceed as if Darwin had never written; collections are arranged in such a way that the phenomena of variation are masked. Their business is purely that of the cataloguer, and beyond that they cannot go."

In another paragraph, he quite frankly admits our ignorance as to the *method* of evolution, in these words:

> As to almost all the essential features, whether of cause or mode, by which specific diversity has become what we perceive it to be, we have to confess our ignorance nearly total.

The concluding paragraph states that:

> As yet the genetic behavior of animals and plants has only been sampled. When the work has been done on a scale so large as to provide generalizations, we may be in a position to declare whether specific difference is or is not a physiological reality.

Published Papers

An attempt has been made to list most of Bateson's publications so that the student desiring to find the refer-

ence to a particular paper may more readily do so. The bibliography, which is admittedly incomplete, contains something over one hundred titles. Short notes, book reviews, critical comments and thoughts on various subjects such as "Compulsory Greek at Cambridge," "Organization of Scientific Work," "Science in Russia," "Classical and Modern Education," etc., have been purposely included, for they illustrate, to some extent, the breadth of Mr. Bateson's interest, and the activity of his mind and pen.

It will be noticed that most of the early papers deal with morphology, with special reference to *Balanoglossus*. As early as 1888, however, a title appears, in which the word "variations" occurs. During the following decade, most of the papers deal with the subject of Variation.

In 1898, two years before the rediscovery of Mendelism, Bateson presented a paper on Hybrid Cinerarias to the Cambridge Philosophical Society, and from 1900 onwards, heredity was the subject most often dealt with.

The crowing of the Bateson cocks, exhibited at a meeting of the Cambridge Philosophical Society in 1905, to illustrate the new "walnut" comb, is still spoken of with considerable delight, by some of the older members of the society.

The historically important, but now discarded theory of reduplication, was advanced in a paper by Bateson and Punnett read at the Fourth International Conference of Genetics at Paris in 1911.

The address delivered at the Toronto meeting of the American Association by Mr. Bateson in 1921, appears under the title "Evolutionary Faith and Modern Doubts." Newspapers played up the "Doubts" part of the title, giving some of their uninformed readers the idea that a leading English biologist entertained doubts as to the *fact* of evolution. This of course was far from the truth. Feeling that this misconception of his paper might have played some part in stimulating the "Revolt Against the Teaching of Evolution in the United States," Mr. Bateson was careful to publish an explanation under that title in *Nature,* a few months after the Toronto incident occurred.

In addition to his own writing, Mr. Bateson did a considerable amount of editorial work. He was Editor of the *Journal of Genetics* from its beginning in 1910 up to the time of his death in 1926.

Some Traits of Character

Two of Bateson's classmates* have recorded some interesting impressions of their undergraduate days and subsequent associations in college life. They recall that Mr. Bateson seemed a sort of living protest against the "average" quality of his contemporaries. He was a man of frank independence in thought, word, and deed, possessed of a personality strongly marked. In college affairs, Bateson always kept the end in view, and made, as a rule, short work of obstacles. He was essentially a man of intuitions and convictions, and was a born leader. He loved to lead a cause and win. He was never for half-measures or compromises. In some ways, his was an impatient spirit. He had little use for idle small talk, though an argument roused him, but chess, whist, or bridge would keep him contented for hours.

Collecting must have been a very early activity in his life. One of his boyhood nurses helped him with a beginner's collection of insects and in later years Mr. Bateson showed his appreciation of this early and friendly help. He later became a collector not only of biological specimens but of coins, Japanese prints, and other arts and crafts, some of which are now deposited in the British Museum, of which Mr. Bateson was an elected trustee.

Among the many fine things said

**The Eagle*, St. John's College Magazine, Cambridge, April, 1926.

and written by friends and colleagues at the time of Mr. Bateson's death, we quote the following:

William Bateson had the rare distinction of combining great scientific attainments with an outstanding capacity for appreciating the artistic, literary and social sides of life. In the language of his own science he was "heterozygous." He was a lover of the classics, and a keen upholder of the value of a classical education; he was widely read in English and French literature, having a special admiration for Balzac, with whose works he was very familiar; although his judgment was not infallible, he was no mean connoisseur of art, and he possessed a fine collection of pictures, especially of early Japanese prints; a judge of good wine and good food—qualities which distinguished his term of office as Steward of St. John's College—he was exceedingly hospitable and an admirable host.

As a scientist he was in no sense a specialist, and he regretted the growing tendency towards specialization, holding, as he did, that the chief hope of great extensoins of human knowledge now lay rather in the field of synthesis than of further analysis, carried out in more or less water-tight compartments by men who were not conversant with what was being done in other departments.

Those who had the good fortune to be numbered amongst his friends will always remember his charm of personality, his great gift of interesting conversation and his wide knowledge on matters outside his own subject.

Haldane, a brilliant thinker and active worker, in the fields of bio-chemistry and genetics, wrote as follows:

The characters which are inherited according to Mendel's laws are so numerous and important, and their possible combinations so enormous, that a lesser man would inevitably have devoted the remainder of his days to following out the detailed application of these laws. Bateson did so up to about 1912, but the last years of his life were largely given over to the investigation of *exceptions* to them, and we owe to him more than to any other one man the demonstration not only that they are valid over a vast range of material but that they occasionally break down. Bateson never tried to conceal his contempt for second rate work and second rate thought, and pursued the truth with no more regard for other people's opinions than for his own. If Bateson had merely demonstrated the truth and importance of Mendelian heredity the world would be his debtor. But he did much more than that. He has probably prevented Mendelism from becoming a dogma.

One of Mr. Bateson's closest associates in Cambridge University characterized him thus:

Fearless in criticism and generous in appreciation, he stood above all for that spirit of freedom in inquiry through which alone the world may progress to better things.

A fellow member of St. John's College, Cambridge, writes:

His enthusiasms were for clear-cut, new ideas. In his scientific work, as in all things that really counted with him, he was filled with a very intense earnestness. Working rapidly but thoroughly through the evidence on complex problems, he could arrive at firm conviction of where the truth lay. He was impatient of expositions which involve elaborate quantitative treatment and then still leave residual expense accounts.

Morgan* has paid a fine tribute to Bateson, characterizing him as a man of outstanding intellect and commanding personality:

The ardor with which Bateson undertook to apply, test, and extend Mendel's discovery, the keenness that he brought to bear on the new work, and the complete frankness with which he discussed "unconformable cases" had a wide influence on the rapidly growing School of Genetics.

Morgan goes on to say:

If Bateson disagreed he said so flatly, and could always give a cogent argument for his disagreement. His intellectual rectitude was beyond all praise and recognized by friend and foe alike.

The more difficult the problem the more it attracted him if it offered an opportunity for exact experimental investigation.

"Treasure your exceptions," he said.

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*Loc. Cit.

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COLOR IN RELATION TO HEALTH

Of Wild and Domestic Animals

S. HADWEN, with a Note by E. L. HARRINGTON
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THE quotations given below of old and of recent work show that there are still differences of opinion regarding the color of animals. The writer ventures to record certain facts which bear on the subject. He believes that white is a poor color for the domestic animals, as regards their health—that it is not natural, and that it has been produced by artificial selection. He bases his ideas principally on experience gained in Canada and in the Arctic regions.

Buxton[2] in a recent work on desert animals states as follows:

> There is no doubt that the color of desert animals is in some way the result of the conditions under which the creatures live, because it is quite characteristic of them, and not of animals from other types of country. Whether this color is due to climate or is protective we do not know. . . . . In many desert animals the under surface is very pale or quite white.

The predominating colors of all desert animals in all countries according to Buxton are isabelline (buckskin) or reddish buff or greyish:

> There is only one important exception to the generalization that desert animals resemble in color the soil on which they live, but it is a most remarkable one; in many deserts a number of the indigenous animals are black.
>
> We must remember that black absorbs more radiant heat than any other color. Presumably therefore a black creature must evaporate more water than a similar buff creature, if it is to keep its body temperature below a certain figure on a particular day. This, one would suppose, would severely handicap the black creatures under circumstances in which water is extremely scarce.

Wallace said, in writing on the constancy of animal color, that:

> The extreme variations in color that immediately arise under domestication indicate a tendency to vary in this way, and the occasional occurence of white or piebald or other exceptionally colored individuals in many species in a state of nature, shows that this tendency exists there also; and, as these exceptionally colored individuals rarely or never increase, there must be some constant power at work to keep it in check. This power can only be natural selection or the survival of the fittest, which again implies that some colors are useful, some injurious, in each particular case. With this principle as our guide, let us see how far we can account for the general and special colors of the animal world.

In his concluding remarks on the origin and uses of color in animals Wallace remarked:

> On a review of the whole subject, then, we must conclude that there is no evidence of the individual or prevalent colors or organisms being directly determined by the amount of light, or heat, or moisture, to which they are exposed; while, on the other hand, the two great principles of the need of concealment from enemies or from their prey, and of the recognition by their own kind, are so wide reaching in their application that they appear at first sight to cover almost the whole ground of animal coloration. . . . . [Wallace remarks that an explanation has been suggested for the white color of Arctic animals] that the white color is chiefly beneficial as a means of checking radiation and so preserving animal heat during the severity of the Arctic winter. . . . [Wallace added, however] This suggestion is also a hypothesis merely, since it has not been proved by experiment that a white color, *per se,* independent of the fur or feathers which is so colored, has any effect whatever in checking the radiation of low-grade heat like that of the animal body.

Hogben[4] the author of a new work on the Pigmentary Effector system of Amphibia, Fishes and Reptiles says:

> One recalls the interest aroused by the observations of Alfred Russell Wallace and his contemporaries on protective resemblance and "mimicry"; the immense importance attached to the subject in the controversies that centered round the truth of the evo-

lutionary doctrine; and the gradual recognition that little profit could be gained from the further discussion of such phenomena except on the basis of genetical investigation, [He adds a little later] to penetrate by experimental inquiry beyond the indolent satisfaction that comes to many minds in contemplating a universe in which there exists an order exquisitely adjusted by the projection of man's native bias in favor of purpose in nature.

This reference shows the modern attitude toward the study of animal coloration. A number of recent papers bearing on coloration have been studied, including genetical investigations, but the question of health, or to give it an old name with another meaning—protective coloration—seems to be left almost entirely to one side, except by medical men and to a lesser extent by veterinarians. It was the old school led by Darwin and Wallace who wrote of color and health, and moreover laid much emphasis on it.

White and Spotted Domestic Animals

It would seem probable that breeders have selected and bred white and parti-colored animals, not on account of their being better or stronger, but because the color effect is pleasing to the eye. In the case of reindeer the Lapps say that they keep a few white animals because these can be easily seen from great distances, and thus help in finding the herds. But the Lapps have another reason for the preservation of white animals; they one and all affect white gauntlets when they desire to be smartly dressed in winter. The Eskimo also delights in a white or spotted reindeer skin, which he makes into a coat (parka) or else into long fur boots.

Quite recently the Clyde breeders are developing spotted and wall-eyed horses. This last example is probably in part accidental through close breeding with a spotted strain.

There are numerous examples of other breeds of domestic animals in which white color markings are carefully preserved, but in no case can the writer find any useful purpose in it as regards the health and strength of the animals.*

ALBINOTIC AND PIGMENTED AREAS
Figure 2

A bay horse with white blaze on face. Inside the right nostril the dividing line between the bay and the white hair is sharp and decided. On the left side of the nose the bay marking shades off gradually into the white. For about half an inch white hair covers pigmented skin, which is lighter in color than that underlying the bay hair. The cross mark indicates the line referred to.

Spotted Black and White Cattle

In Canada, Holstein Friesian cattle often suffer from the effects of sunburn. The white parts of the skin become scalded and sore, and in severe cases a dermatitis may follow, causing portions of the skin to slough away. If these skin lesions are examined closely

*In a personal communication Dr. E. W. Nelson of Washington informs me that when domesticated cattle and horses, which always have more or less white or spotted individuals among them, are permitted to revert to a wild state for a long period, they almost always breed back to a general uniformity of color such as characterizes any wild species.

WHITE REINDEER
Figure 3

The characteristic dark iris indicates that white reindeer are not true albinos, and no pink-eyed reindeer have ever been seen by the author. White reindeer are deficient in many respects: their eyes are weak, and they sleep much of the time. As a result they are easily approached and become the prey of wild animals. Lapp herders value a white animal here and there as an aid in locating the herd at a distance. (Courtesy U. S. Biological Survey.)

it will be seen that the burn ends abruptly at the junction of the white skin and the black. The skin underlying the white hair is unpigmented and pink, which accounts for its great susceptibility to sunburn. It must be remembered that Holstein cattle are dairy animals and that consequently they are housed and liberated at irregular intervals, which predisposes them to sun scald. Darwin mentioned cattle a number of times in his writings, quoting various observers who had seen skin lesions in white or spotted cattle, and he evidently believed that white was an unsuitable color.

In both cattle and horses a curious distribution of pigment has been observed round albinotic areas. The dark edges may taper off into the depigmented part very gradually, so that there is a zone which is neither one color nor the other. Generally the line between the white and black is sharply defined. This tapering process suggests that the invading pigment was slowly arrested in its advance by some inhibiting agent. The writer is attempting a study of these areas. (Figure 2).

White Pigs

These animals are great sufferers from sun scald at certain seasons of the year. In the worst cases nearly the whole of the skin of the back has been known to slough away. Black pigs living under the same conditions suffer no harm. In this connection it is interesting to recall Darwin's quotation of Heusinger, "it appears that white sheep and pigs are injured by certain plants, whilst dark-colored individuals escape." Darwin also quoted Wyman "we select the black members of a litter (of pigs) for raising, as they alone have a good chance of living."

Fagopyrismus sensitization of the

PIGMENTED SUMMER COAT
Figure 4

A Norwegian reindeer. Tromsdal, Norway, Aug. 17, 1926. The summer coat is thinner than the winter coat, and the hair is more shiny. The change in color is not so marked as with some arctic animals, but the color change serves the same purpose, as a protection from the actinic rays of the summer sun.

white parts of the skin to the sun's rays occurs in man and animals in countries where buckwheat is grown. This affectation only attacks the unpigmented parts of the skin. In some districts of Ontario where alsike clover is grown extensively, it is reported that skin troubles have been noticed in grey or white horses. These animals suffer from an eruption round the feet and mouth when they are out at pasture. A similar occurence has been noted in Australia. In Western Canada the writer has seen pigs, which were grazing on Lucerne, badly sun scorched.

White Reindeer and Other Arctic Animals

In a study of reindeer both in Alaska and in Lapland the writer has stated[3] that white reindeer are deficient animals. White reindeer occupy an anomalous position in the summer time amongst other Arctic terrestrial animals: inasmuch as they remain white throughout the season. In winter they appeared to be almost normal, but in the summer they were found to be deficient in vision, hearing, and sense of smell. Darwin's statement that white cats with blue eyes are deaf has, perhaps a wider significance than he realized. White reindeer have sleeping propensities in the sunlight, and it is possible to approach them, and even to catch them at times. The Lapps are well aware of this fact and say that such individuals become the prey of wild animals more easily than rein-

REINDEER IN WINTER

Figure 5

It will be noticed that the coloration is light, with the exception of the dark legs and the strip along the flanks. Photographed near Iditarod, Alaska. (Courtesy U. S. Biological Survey.)

deer having the natural color pattern. They are not true albinos as the iris is pigmented a bluish grey, giving a wall-eyed appearance. (Figure 3.) The eyelids are pink and the skin of the body is also depigmented. In the sun the eyelids are kept half closed and the eyes have a watery appearance. In no instance was a true pink-eyed albino encountered. The horns are pink, and in the vascular growing stage are usually sore and scabby from sun scald. The ends of the horns are rounder and blunter than is the case in normal healthy animals. In parti-colored reindeer where the horns are often splashed with white, these portions may become sun scalded and the darker parts remain quite healthy. Reindeer shed their hair rapidly when warm weather approaches, the bucks first in May, then the younger animals and finally the does, the whole process being over early in July, except in the case of old or diseased animals. The color of the new hair is dark—almost black in some cases (Figure 4). This is true also of the young fawns which are dropped from the middle of April to the fifteenth of May or thereabouts. Their coloring is like that of the northern Mink, a rich dark brown. The hair gradually becomes lighter as the season advances, except for a line along the flanks and the lower part of the legs, and when the autumn is reached, the general coloring is of soft yellows, browns, grey and white. (Figure 5). The period of the year when the hair is darkest is during the long hot sunshiny days. These changes are not as rapid or as early as those which occur in the white foxes, rabbits or ptarmigan, but they are the same in effect. To sum up—white reindeer suffer from sun scald because they do not change color in summer—the normal animal after shedding its winter coat grows a dark, thinner coat of hair, to protect itself against the sun.

FLEA-BITTEN SPOTS ON OLD WHITE HORSE

Figure 6

These spots are rusty red in color. As animals grow older their hair becomes less pigmented; the formation of such spots appears to be due to the skin's taking over the light-protective function of the hair.

The writer believes that this paragraph and the following ones answer Buxton's queries (mentioned in the forepart of the paper) about the black coloration of desert animals.

The Reason for Sun-scald and Dermatitis in Domestic Animals

It is quite clear that simple sun-scald occurs most frequently in animals which have been housed and then turned out into bright sunshine. It is probable that the difference between the sensitization caused by the ingestion of vegetable proteins and that due to simple sun scalding, is that in the first instance the animals may show symptoms while living constantly out of doors, and in the other they only develop serious lesions when they are suddenly exposed to the full force of the sun's rays after a period of confinement. In the case of the white reindeer mentioned above, housing does not enter into the problem at all. The sun-scald occurs on the horns in the very vascular growing stage. They are exposed to the full effect of the sun, day and night (in the Arctic regions) and the horns are unprotected except for a downy growth of hair. It must be mentioned also that when reindeer are what is called "close herded," which is a common practice of the Lapps, they get little opportunity of finding shade. In wild animals which have the coloring best suited to their needs, it is doubtful if sun-scald ever occurs except in piebald or albino individuals, and even then the fact of their being constantly exposed to the elements would tend to modify the symptoms shown.

Melanotic Tumors in White Horses

It is a well known fact that dapple grey horses turn gradually whiter as

ALBINOTIC AREAS CAUSED BY CAUSTIC

Figure 7

One horn of the animal pictured was treated with caustic about four months before, in an effort to arrest its growth. A white patch in the velvet shows that some injury was done to the horn cells, but the caustic also stimulated their growth.. The treated horn became much larger than the untreated one. (Courtesy, U. S. Biological Survey.)

they advance in years. The production of melanin which once colored the hair, though it is no longer required for that purpose, may still go on, and it is not uncommon to find large accumulations of melanin forming tumors in old white horses, especially round about the anal region.

The writer has never seen the tumors in unbroken wild horses such as one finds on the ranches of the prairies. He has made enquiries among those who have had much experience with these animals, and so far has not been able to hear of a case. If it could be definitely proved that only those horses which have been deprived of a certain amount of sunlight become affected with tumors, and that those which live permanently out of doors are not so affected, then it would show the exact use of the pigment in the animal economy. It cannot be stated that grey horses living constantly out of doors do not become whiter with age, but though the hair may become lighter, the skin probably retains more pigment than is the case with stabled animals. The flea-bitten spots (rusty red) which are common in old grey and white horses might be taken for an indication that the skin is defending itself against the sun because the hair has lost its pigment (Figure 6). Melanotic tumors are sometimes found in animals of other colors, but the condition is more common in white horses, and it is safe to say that they are more predisposed to it.

The late formation, and generally benign nature of the tumors, indicates that melanin is constantly produced at a time when it is not required, so that its production does not appear to be effectively controlled. This hypothesis gains support by the fact that many of the glands, far removed from the seat of the trouble are often filled with pigment.

Injuries to the Skin and the Growth of White Hair

When the skin has been severely injured through a cut or burn, the new hair usually comes in white, and it persists for life. This is generally the rule with all animals. When the injury is more superficial the new hair may not turn white but sometimes it grows in a little darker than it was before. In some instances the injuries would appear to be almost too trivial to induce the growth of white hair, and yet it occurs. For instance, after a simple tick bite, a minute patch of white hair may make its appearance, so that in a tick infested country it is a common sight to see black and bay

horses covered with little white tufts of hair. (Figures 7 and 8.)

The conclusion to be drawn from this would be that the skin may lose its power of pigmenting the hair after injury, though it is still able to produce hair. Therefore, white scar tissue which produces white unpigmented hair can be compared with the unpigmented skin and hair on certain animals, and such skin must be regarded as defective.

According to Burgess "Meirowsky demonstrated beyond any question of doubt that melanin is formed by epidermal cells, but the origin of the pigment found in the pigment-bearing cells of the cutis is still a subject for argument and surmise." Burgess quoting Block says, "as a result of his experimental work, (with dioxyphenylalanin) held that pigment production in the skin is the result of the action of a specific ferment, and is intimately bound up with an oxydation process." If this view is correct it must be concluded that albinotic areas of the skin and scar tissue are unable to produce the specific ferment.

Mudge[6] writing about albino and particolored animals, and of cutaneous diseases of unpigmented parts says, "Such cases suggest that we should be more correct in regarding, not albinism as correlated with constitutional defects, but rather pigmentation as correlated with powers of immunity or increased resistance against certain injurious processes."

Mention should also be made of Keilin's remarkable work on Cytochrome which he describes as "an intracellular respiratory catalyst common to animals, bacteria, yeast and higher plants.

The White Coloration on the Bellies of Animals

Poulton[7] quoting Thayer regarding the white coloration on the bellies of animals, says: "that this gradation obliterates the appearance of solidity which is due to shadow."

Contrary to Thayer's view it would seem probable that the lighter coloration on the bellies of animals is due to the parts being shaded and not exposed to the sun's rays. Without entering into a discussion on protective coloration, the writer wishes to point out that if the skin of the back were replaced by the scantily haired, thin skin of the belly, that the animals would surely suffer from sun scald. The thinness of the skin and scanty hair covering allows for the elimination of waste products and would tend to keep an animal cooler. The heat affecting the skin of the belly must be largely reflected up from the ground, instead of striking directly from above as it does on the back—hence the harmful actinic rays would be eliminated.*

The Coloration and Thickness of Skin and Hair

In domestic animals light or white hair does not necessarily mean a depigmented skin, because certain strains of cattle like the Shorthorn may have yellow skins. White hair sometimes lies over a dark skin. In the tropics black, thick skinned, hairless animals occur.

The author's observations indicate that length of hair is in inverse ratio to the thickness of the skin; in all the long-furred northern animals, the skin is very thin. Thus the hair may protect the body or the skin perform the same function.

Certain colors such as brown, black, bay, isabelline, or roan are good, and white is apparently the only color which is deficient in protective qualities against the sun. This statement is not out of harmony with the change to white in northern mammals. If white is not a good protective color in summer it may be beneficial during the winter when the animals are on the snow. The reflections from the snow added to the sunlight may be another factor in the case. Anyone who has traveled much on the snow will realize this.

The writer has often seen ptarmigan sunning themselves, evidently absorbing as much of the sun's rays as they could—on the other hand hares and

*The late Sir P. Manson said: "The natives in warm climates invariably have dark skins; a natural protection against the actinic rays of the solar spectrum."

other mammals seem to stick to their nocturnal habits as in warmer climes. But since it has been recorded, during mild winters, further south, that they do not change color, there is no doubt that the change is related to cold weather and to snow. The coat of a fur bearing animal in winter stands up and is open. The arrector pili muscles function much more than they do in summer because at this season the hair lies flat. Another noticeable thing about the hair is that the winter coat has a dull appearance compared with the summer hair which is much more brilliant and shiny. This is mostly in evidence when the new growth of hair appears in the spring. In birds and insects the black species shine much more than those which are brown or buff colored. Refraction must have an important bearing on the absorption or deflection of heat rays.

In larger domestic animals such as cattle the thickness of the hair seems to play a more important part than color in protecting them against the cold. This is because breeders have not considered protective colors in mating their animals. Examples of this can be given. Some years ago in Canada it was a common practice to bring large numbers of cattle from Texas to graze on the Western Prairies. The effect of the Canadian climate on the cattle was to stimulate a heavy growth of hair which in turn caused the skin to become thinner. So that when the cattle were slaughtered there was a distinct loss in the quality of the hides. In reply to a circular letter sent to Canadian tanners, it was found that they were all in agreement over the fact that long haired rough cattle had thinner and poorer hides than similar strains of animals which had been stabled. From this it is clear that a cold climate stimulates a growth of hair at the expense of the skin.

Function of Winter Coat

Speaking of northern animals Poulton says:

> The white winter coat is chiefly for concealment, but may also help to retain heat.

Certain northern animals, especially those frequenting trees, do not become white in winter; this is true of the Glutton (*Gulo luscus*). Occasionally dark winter individuals occur in species which as a rule change their color regularly, thus, a black Arctic Fox is well known, but its rarity (Sir J. Ross found three individuals out of fifty white ones) probably indicates that it is, as we should expect, at a disadvantage, and that it will disappear.* Mr. Wallace considers that the dark color of arboreal northern animals, which is clearly for concealment, disproves the theory that the white color is of value in retaining heat. But it does not follow that such benefits are wholly non-existant, because they must be dispensed with under the pressure of a stronger necessity. Mr. Wallace's argument shows that concealment is of paramount necessity; but this does not disprove the opinion that other advantages also may be conferred by a particular mode in which concealment is attained.

One important fact has been omitted by Wallace and Poulton in connection with these arboreal mammals—that some of them are nesting animals and others live in dens during the day time. On the other hand the white fox is distinctly a migratory animal and follows the ice in winter. (Figure 9). The northern hare does not burrow and the polar bear follows the ice all the year round and does not require to change color at all. These facts might be interpreted in favor of white as the most suitable color for winter life in the open. And if white is better for concealment it may be better also for the health of the animal. The coloration of wild animals is so wonderfully uniform and constant, and the seasonal changes so regular and necessary that it would seem that the health of the animals came first and that other considerations are subservient to this.

Biting Flies and Other Insects Attracted to White Animals

Darwin said: "With cattle susceptibility to the attacks of flies is correlated with color, as is the liability to be poisoned by certain plants, so that even color would be thus subjected to the action of natural selection." Why are biting flies attracted to white animals? The answer is not easy unless it

*This statement about black and white foxes is not correct because the two species are distinct, also the black fox is quite hardy and is being successfully raised in captivity.

ALBINOTIC SPOTS DUE TO FLY INFESTATION

Figure 8

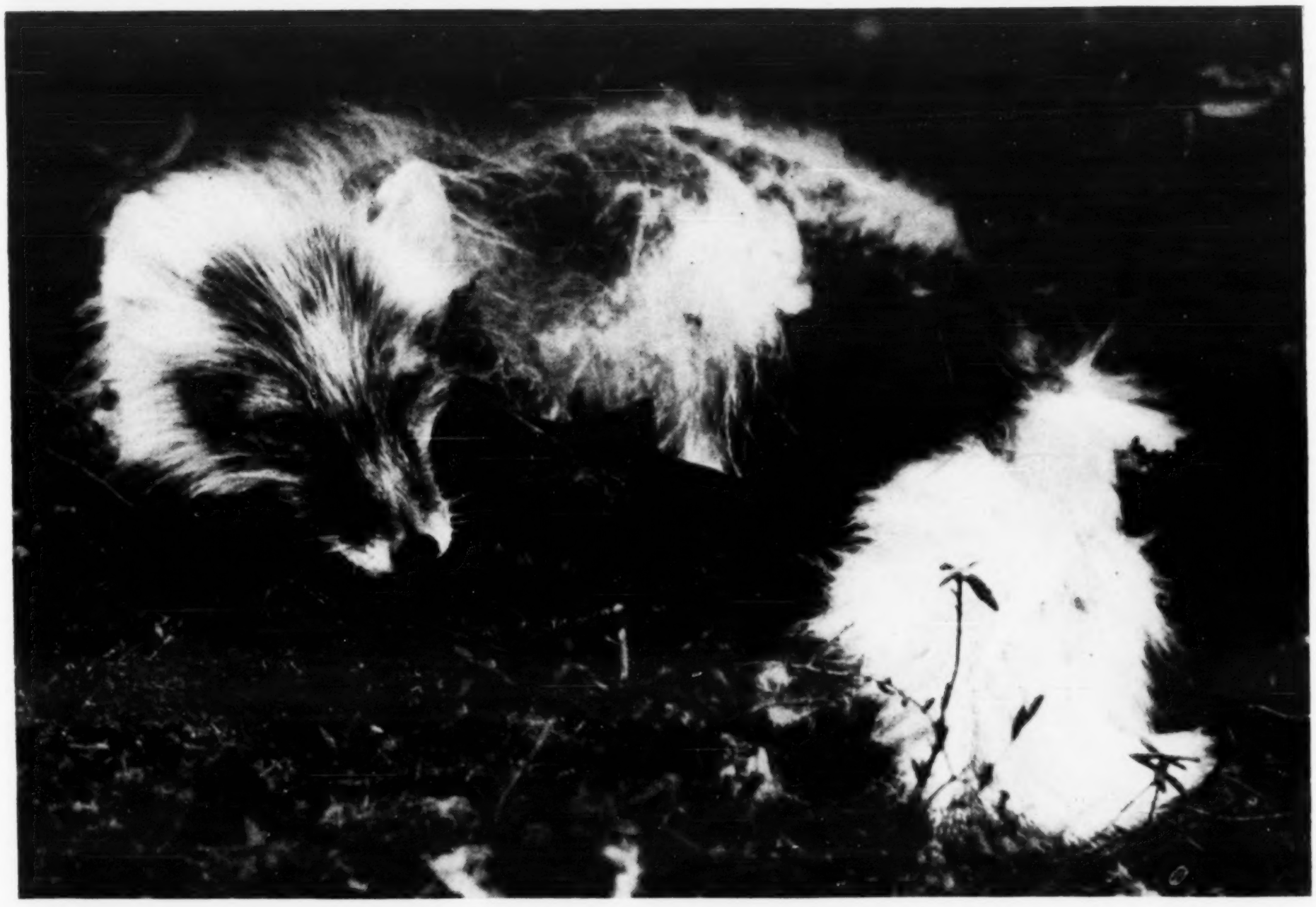
The spots of light-colored hair on this reindeer's back, indicates a previous infestation with *Oedemagena tarandi.* Buckland River, Alaska, August 14, 1921. Very trivial injuries sometimes produce such spots, and in other cases the hair comes in darker. (Courtesy, U. S. Biological Survey.)

be a question of temperature or some other physical factor. Darwin wrote "flies" without mentioning what kinds of flies. With regard to Muscid flies it is easy to see why they are attracted when we know that white cattle often discharge from the eyes, or else when skin lesions are present the discharges are eaten. The Warble-fly of reindeer (*Œdemagena tarandi* L) and *Cephenomia trompe* (L), the nostril fly, parasitize white reindeer more than the darker colored animals. All reindeer men firmly believe this is due to color, but the writer found that there were other reasons which enter into the case, and some of them might apply to cattle As white reindeer are sleepy, listless individuals, the flies have a much better chance to attack them than the more active animals. Oviposition is such a pressing need with the short lived *Oestridae* that the insects lay their eggs on the nearest victims who will submit to their attentions. There is no attempt at selection on the part of the insect and *Œ. tarandi* has repeatedly been seen in numbers busily ovipositing on dying animals. *Œ. tarandi* resembles *H. lineatum,* one of the cattle Warble-flies, in one respect—it has a way of attaching its eggs to the hairs of a recumbent beast without actually resting on it. The fly remains on the ground, reaching up with its long ovipositor to affix its eggs, so that in this instance the insect would obtain no benefit from alighting on the animal's skin, even if such benefit were to be had. Another observation made in Alaska shows how little the insect cares where it deposits its eggs. To a freshly captured fly held by one wing, a tuft of reindeer hair was applied to the abdomen. The insect's ovipositor at once began to dart about among the hairs and 51 eggs were laid. In the case of *C. trompe* which hovers in front of the reindeer's nose and then darts in to deposit living larvae on the mucous membrane, quick sighted and active reindeer have been observed to close the nostrils or move the head quickly enough to outwit the insect. It is obvious then that a watery-eyed. listless, white reindeer would be at a disadvantage under such conditions.

Summary

Buxton in a recent work on desert animals considers black an unsuitable color for them.

Wallace said that white or piebald



COLOR CHANGE IN THE ARCTIC FOX
Figure 9

Photographed near the mouth of the St. Lawrence River, June 4, 1922. The dark summer coat has about half replaced the winter coat. There are two species of arctic foxes, one that remains pigmented throughout the year, and one that changes color with the seasons. The white fox follows the ice in winter. Arctic animals that nest in trees or live in caves during the day do not change color.

animals rarely or never increase in a state of nature. He believed that Arctic animals are white because the color is protective, and is not otherwise beneficial.

The writer's opinion is that white and spotted domestic animals are deficient, and that they are perpetuated for no useful purpose—simply to please the eye.

In Canada spotted black and white cattle often suffer from sunburn, and white pigs have been known to lose the entire skin from the back.

Fagopyrismus occurs in Canada, also sensitization of the skin following the ingestion of other plants besides buckwheat. White reindeer do not change color in summer like other arctic animals and suffer from sun scald. They are not true albinos but are nevertheless deficient in vision, hearing, and sense of smell.

It is shown that arctic animals acquire a darker coat in summer as a defence against the sun's rays. The white winter coat is the most suitable color for winter life in the open. Sunburn in the domestic animals is often the result of intermittent exposure to sunshine, through stabling. When the animals have become sensitized through eating certain plants, it is suggested that the skin eruption may come from that cause alone, and that it is simply aggravated by sunshine.

Melanotic tumors which are common in old white horses have not been observed in animals living constantly out of doors. Slight injuries to the skin may intensify the color of the hair, but more severe lesions often result in a total depigmentation of the skin and a growth of white hair. Hence scar tissue producing white hair is

comparable to albinotic skin and is regarded as defective.

The white coloration on the bellies of animals and the thin skin and scanty hair is believed to be beneficial, allowing as it does for sweating and for coolness. This is contrary to the views of Thayer.

The coloration and thickness of the skin may protect the body against the sun, instead of this function being performed by the hair.

In northern animals the skin is thin, in summer the hair lies flat, in winter the hair is long and erect.

Dark coated or black animals and birds are much more shiny than those colored buff or brown. Many black insects are also shiny.

In speaking of the protective coloration of northern arboreal animals Wallace and Poulton do not mention the fact that many of them are nocturnal feeders or else have hibernating habits. Darwin's observation about flies attacking white animals more than darker colored, is confirmed, but additional reasons are put forward to explain the fact.

In an appendix to the article Dr. Harrington expresses his views concerning the physical side of color, he confirms some of the facts expressed in the paper.

Protective Value of Hair

E. L. Harrington
University of Saskatchewan

After considering the facts put forward by the writer, Dr. Harrington makes the following comments on Buxton's work:

Buxton's difficulty appears to be on account of the prevalence of black animals in the desert. He is quite right in accepting the principle that black does absorb more radiation, but may it not be possible that this very fact makes it suitable rather than otherwise? The sun's radiation does not hurt the hair but rather the body under the hair. Black hair would absorb radiation to a high degree and thus prevent it reaching the body. The hair may get very hot, particularly on the outer surface, but it is such an extremely poor conductor and a good radiator that the heat is lost by radiation rather than conducted to the body. In the other case, white hair would reflect rather than absorb, and by repeated reflections from the hair surface to hair surface the radiation would in a large measure reach the body of the animal where it would be absorbed and cause discomfort. If a light skinned person in a well darkened room holds his hand in front of a strong light he finds convincing evidence of the translucency of his body tissues to radiation. An African native would scarcely get the same result. It would seem that a desert animal might well profit by hair that would absorb radiation rather than transmit it like a white window shade, to the body, and that bodies without hair should have pigmented skins to cut down the radiation reaching live tissues. The recent studies on the physiological effects of ultra-violet radiation would appear to greatly strengthen this point of view.

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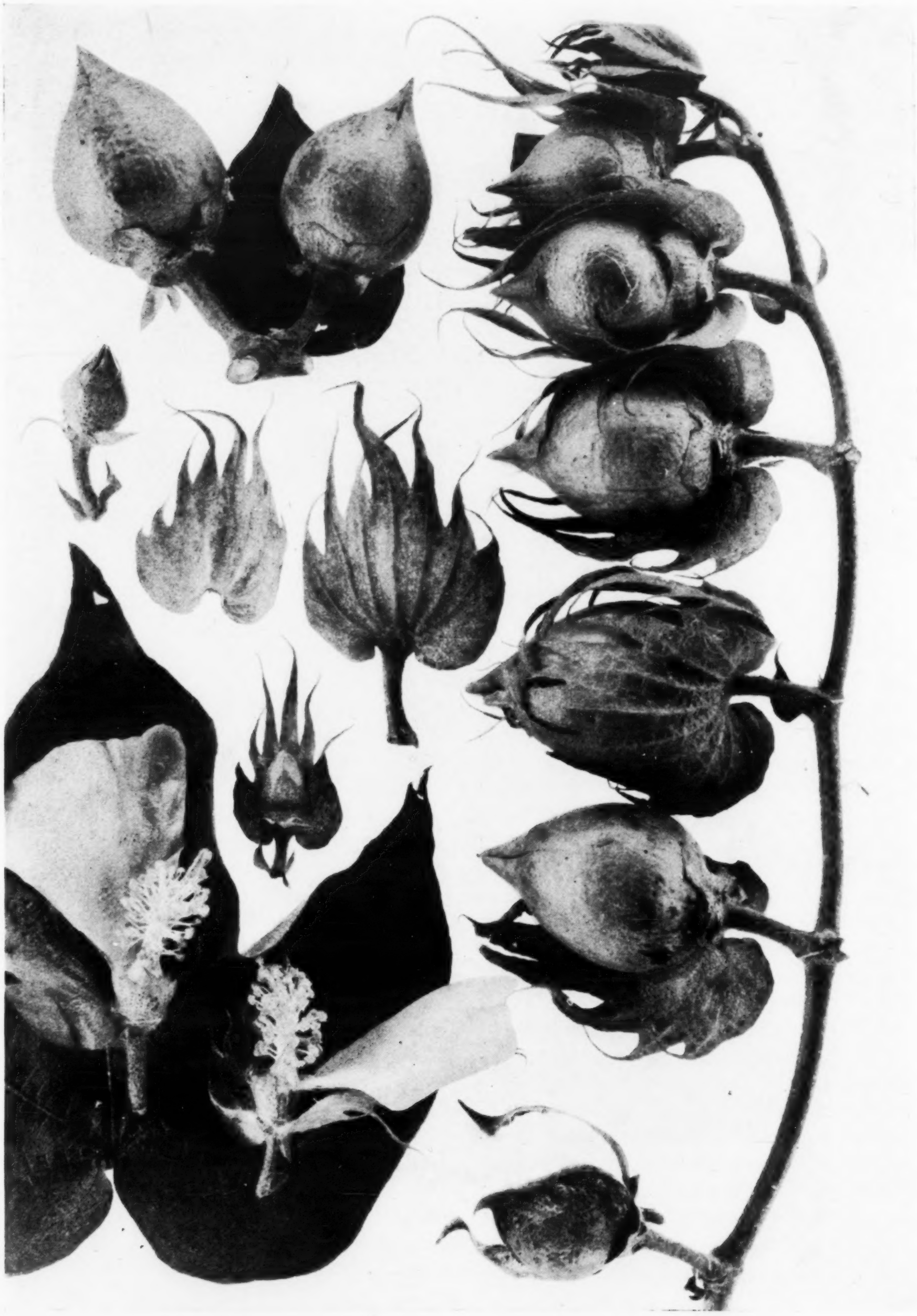


WILD COTTON OF SONORA COAST SAND-DUNES

Figure 10

This cotton was found among the sand-dunes near the coast of the Yaqui Valley, and is the only lint-bearing species in northwestern Mexico that is known to be growing in undisturbed natural conditions. It is a very fertile type, with long, short-jointed fruiting branches, commonly maturing a boll at each node, and often two bolls at the same node; one on a very short secondary branch, as shown at the top of photograph. Seed from the wild plants was obtained by Dr. A. W. Morrill and planted at Los Mochis in 1925. The plants at Los Mochis appeared very uniform and productive, so that possibilities of commercial development may be recognized in this species. *Gossypium morrilli* (natural size.)

PRIMITIVE COTTONS IN MEXICO

Characters of Native Cottons Including a Wild Species

O. F. Cook and J. W. Hubbard
Bureau of Plant Industry

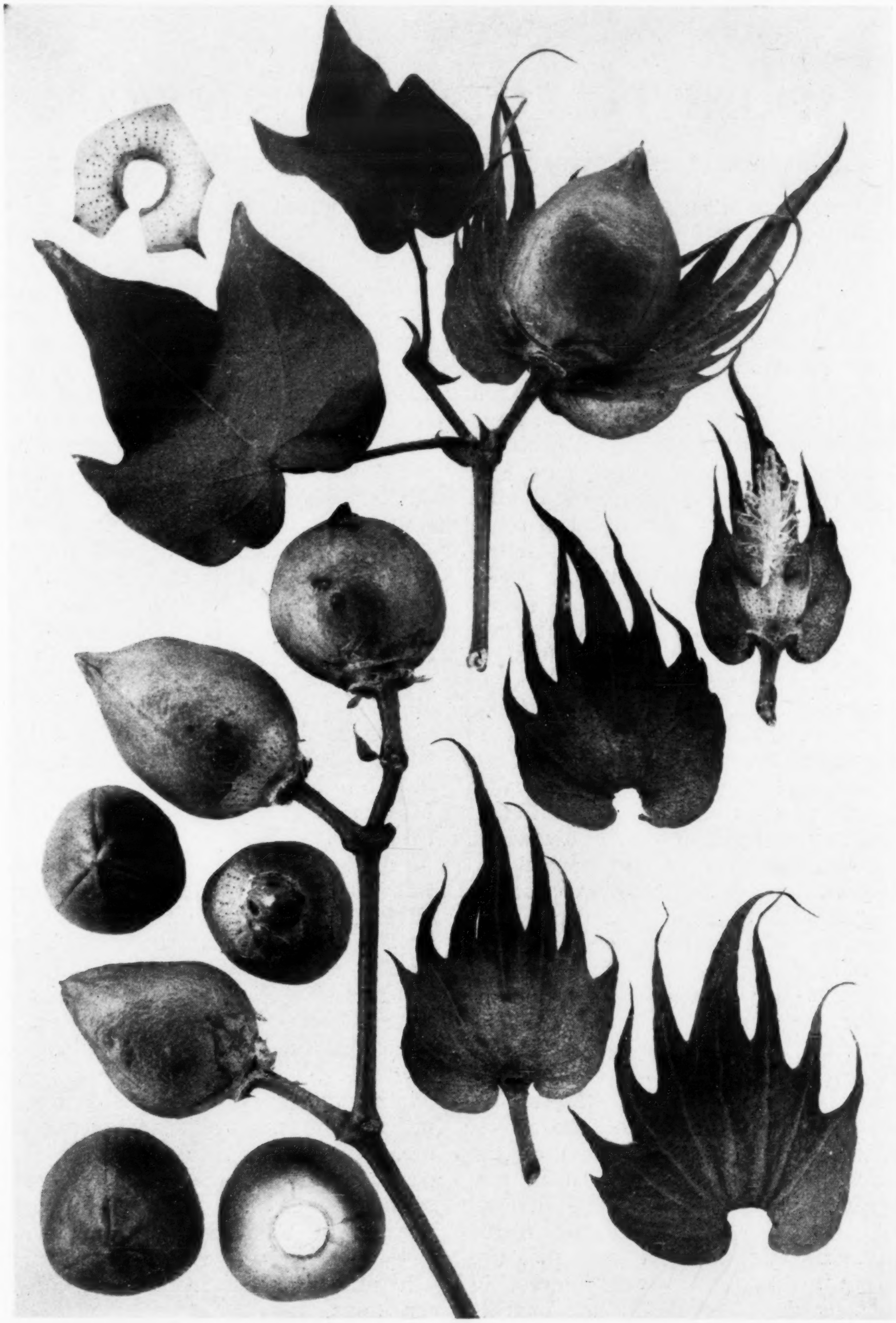
THE study of heredity makes new demands for knowledge of the characters that appear in the different species or varieties, or among hybrids. Hybrids between different species of cotton usually are intermediate in the first generation, while in the second and later generations a wide range of diversity appears, not limited to combinations of the usual parental characters, but including many characters that were not shown by the parent stocks. The question then arises, should such outlying, extra-parental differences be considered as new characters, as reversions to primitive characters, or as reappearances of submerged or recessive characters that trace back to crossing with other species?

For answering such questions, a greater familiarity with the different characters is necessary, to know where they occur in regular and normal expression, and where they appear as abnormal or sporadic variations. If primitive characters reappear in hybrids, hybridizing experiments may make it possible to determine the relationships of the different types of cotton, by observing the reactions between the different characters. Breeders and students of genetics are interested in knowing the full series of characters, and the extent to which each of the characters has been developed in any group of plants that is being investigated. To see the wealth of forms that nature affords is a keen pleasure to the investigator. Such interest in observing and formulating the characters of the different types of plants makes it possible to develop the special knowledge of a group like the cottons, and to select from the storehouse of nature the forms that are best adapted to the use of man.

Five new species of cotton plants have been described recently from northwestern Mexico, with several peculiar characters not previously recognized or recorded, which are likely to be of interest to breeders and students of heredity. Other cottons have been studied previously in southern Mexico, below the Isthmus of Tehuantepec, and in Guatemala, from which the native cottons of Sonora and Sinaloa are quite distinct. Some of our best varieties of Upland Cotton have been introduced from Mexico. The Acala variety was discovered in the state of Chiapas in 1906. The Texas Big-boll type, represented by such varieties as Mebane, Rowden, and Lone Star, is supposed to have been introduced in the period of the war with Mexico, probably by soldiers returning to Texas.

A short visit to northwestern Mexico was made by the writers in December 1925, including the districts of Guaymas, Esperanza, Cocorit, and Cajeme, in Sonora, and of San Blas and Los Mochis, in Sinaloa. Native "tree" cottons were found in each locality, either in the door-yards or along the road-sides. Though not regularly cultivated, the plants are allowed to grow and the cotton is collected for domestic use. Studies were made from the living plants, and natural-size photographs recorded many features that are preserved with difficulty or are entirely lost in dried specimens, and hence are generally omitted from botanical rescriptions.

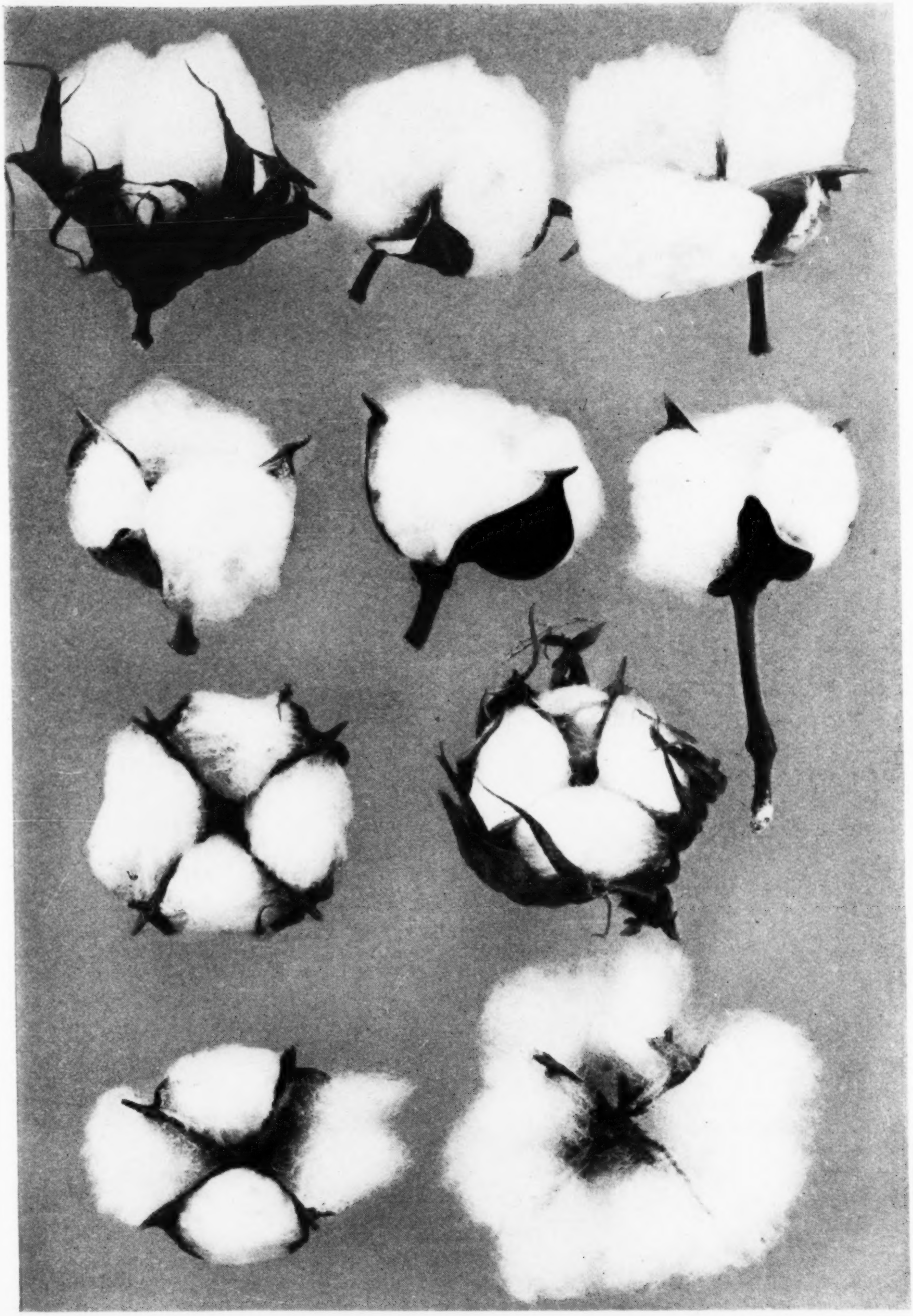
In two localities near Guaymas, *Gossypium davidsoni* was found in abundance, growing as a wild plant among other desert vegetation. This species has no lint on the seeds, but only a short brown fuzz. Much of the



A MEXICAN STORM-PROOF COTTON

Figure 11

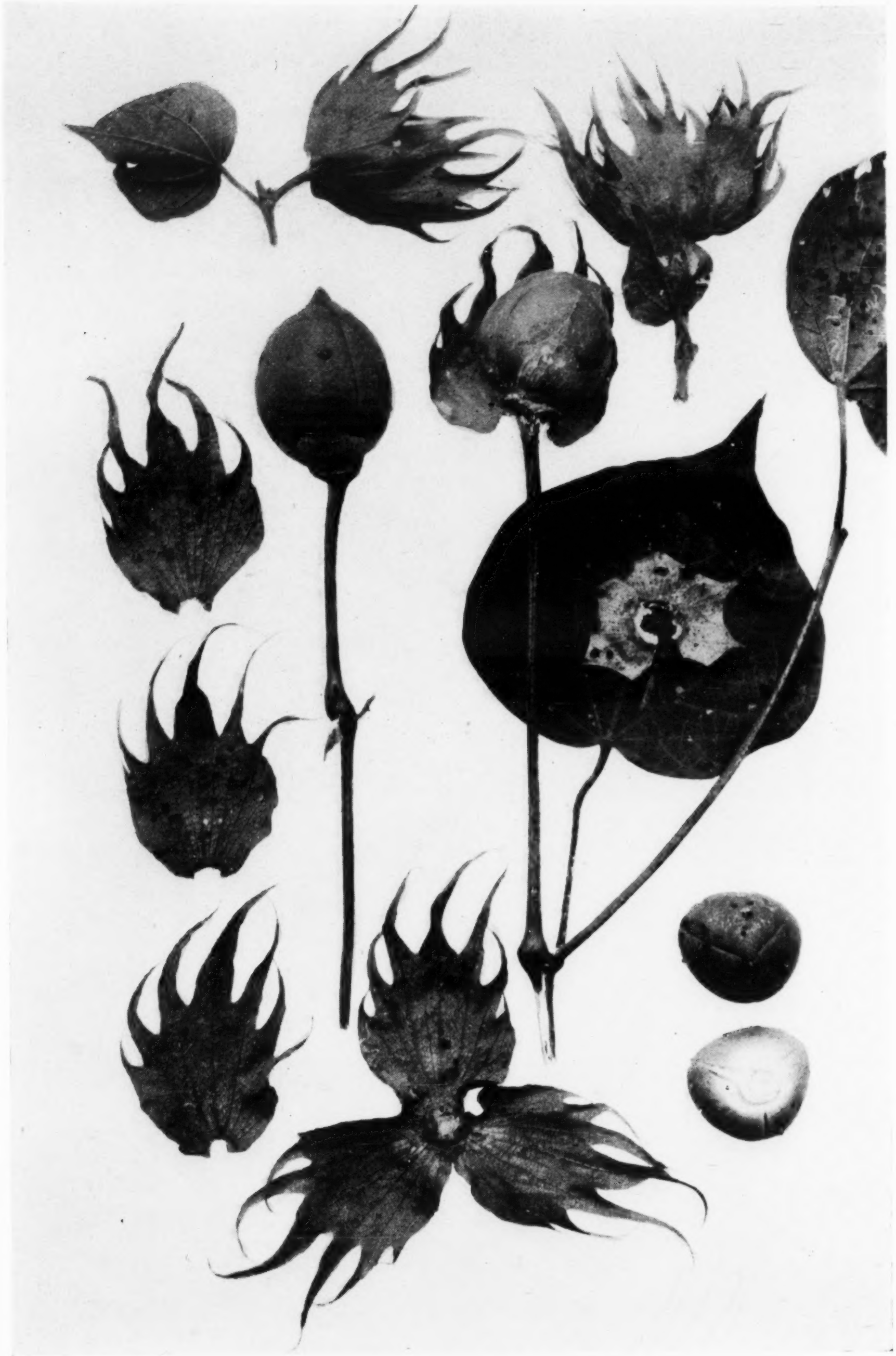
A remarkable adaptation for retaining the seed cotton in the open bolls was found in this species, as explained in figure 12. Other features of interest in this species are the peculiar flat-sided bolls, having a square or triangular appearance in the cross-section, especially above the middle, and the absence of oil-glands from a vertical band in the middle of each division of the boll, over the suture. The calyx has long-pointed lobes, and bractlets are of frequent occurrence, often two or three to an involucre. *Gossypium contextum* (natural size).



COTTON HELD IN OPEN BOLLS

Figure 12

The most striking peculiarity of *Gossypium contextum* is the holding of the cotton in the open bolls, because many of the fibers are attached to the carpel walls. Instead of the locks of seed cotton expanding and pushing out of the open bolls as in other species, the cotton of *G. contextum* is held firmly in a compact mass. The three bolls at the top are *G. morrilli,* and show the usual behavior of seed cotton, "fluffing out" of the open bolls, while the other bolls are of *G. contextum* and show the cotton held in place. The two lower bolls show the fibers remaining attached to the carpel walls after the seed has been removed (natural size).



COTTON WITH OPEN INVOLUCRES

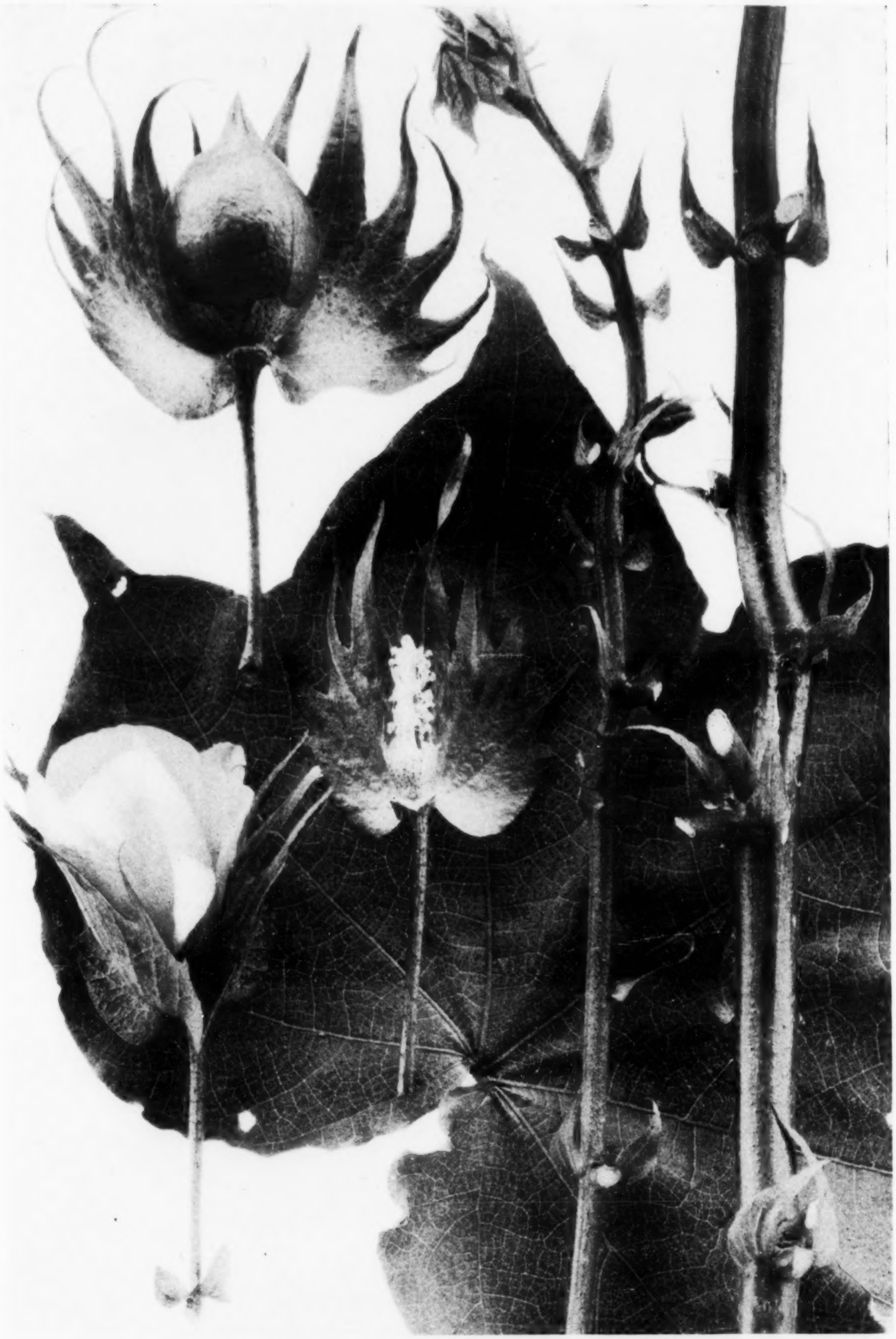
Figure 13

A primitive type of cotton at Guaymas, Sonora, with very small bolls and open involucres that afford no protection against boll-weevil. The bracts that form the involucre are narrowed at the base, instead of expanded into broad basal auricles as in the other species. A double involucre with two sets of bracts is shown at the right, several examples of this variation were found. The very long slender pedicels, swollen at the base, are also characteristic of this species, *Gossypium patens* (natural size).

CHARACTERS OF THE DOUBLE-BRANCHING COTTON

Figure 14

One of the Mexican cottons is characterized by the production of a vegetative and a fruiting branch from the same nodes of the main stalk, a peculiarity which suggested the specific name, *Gossypium dicladum*. Other diagnostic features of this species are the flowers with large white petals and conspicuous red petal-spots, the short style, with the stigma not exserted beyond reach of the stamens, and oval or elliptical bolls, broader in the middle than at the base (natural size).



A COTTON WITH NEW CHARACTERS

Figure 15

A native cotton of Sinaloa with several characters not previously recognized, the leaves borne on erect or ascending petioles, the leaf-lobes broad and flat, and the margins strongly undulate. The outer nectaries of the involucre are not in the usual position at the base of the bracts, but farther down on the pedicel and having the form of a narrow longitudinal groove, like the nectaries on the midveins of the leaves. The flowers are pale yellow with no petal-spots. The bolls are rather small and pointed, with oil-glands absent on a median band of each division of the boll. The name of the species was suggested by the peculiar position of the nectaries, low-nectary cotton, *Gossypium hypadenum* (natural size.)

desert country in Sonora and Sinaloa has been explored by Dr. A. W. Morrill without finding any of the lint-bearing cottons growing in undisturbed natural conditions, with the single exception of a cotton that grows on sand-dunes near the coast in the Yaqui Valley, below Cajeme. Seed of this was obtained by Dr. Morrill and grown with several other native cottons at Los Mochis, so that direct comparisons of the living plants were made. The sand-dune cotton proved to be quite different from any of the door-yard and road-side forms that Dr. Morrill had collected at Los Mochis, and from those that were studied in other places. The species has been described as *Gossypium morrilli*.*

As might be expected from the condition of free hybridizing that exists among the native cottons, a wide range of diversity is found, but with several notable peculiarities that indicate a former existence of several distinct species in northwestern Mexico. Districts that may have been completely isolated during the pre-agricultural ages, have in later periods of deforestation been converted into continuous stretches of open country, and the areas of distribution of the native cottons greatly extended. Also it may be supposed that most of the cottons of the districts visited in this expedition came originally from farther south.

The chief object in describing and naming some of the peculiar forms as new species is to facilitate further studies of the characters. Although it has been recognized that the present combinations of the characters may be due to hybridization, it seems probable that the outstanding peculiarities were derived from species that had a separate existence formerly, if no longer to be found in a strictly wild state. To describe characters without referring them to any species would lead to confusion, as would also result if the Mexican cottons were assigned wrongly to species from other regions, on account of superficial similarities.

Specialized Vegetative Branches

The production of two branches from most of the nodes of the main stalk suggested the name *Gossypium dicladum* for one of the Mexican species. The two branches are different in structure though having the same function. One is a fruiting branch, with a flower-bud at each node, while the other is a vegetative branch not bearing flowers and bolls directly, but on short secondary branches. The vegetative branch is held in a horizontal position like the fruiting branch, not in an ascending or upright position like the usual vegetative branches of cotton, that develop from the lower joints of the stalks. Usually the vegetative branch as a whole is not much larger than the fruiting branch of the same node, and not infrequently it is smaller.

A modified branching habit in this species is indicated also by a tendency of the lower fruiting branches to grow quite large and produce vegetative branches from axillary buds. In some cases several vegetative branches develop from one fruiting branch. But these vegetative branches on the fruiting branches are of the same horizontal fruiting type as the vegetative branches on the higher nodes of the main stalk, and with many short, tertiary branches that produce bolls.

Leaves With Broad Auricles

With respect to leaf characters, a general similarity may be recognized in several of the new forms from Mexico, in the greater breadth and depth of the auricles at the base of the leaves, back of the point of attachment. The expansion of the base of the leaf is carried so far that the auricles often overlap, and thus suggest a peltate leaf.

*See Cook, O. F. and Hubbard, J. W., New Species of Cotton Plants from Sonora and Sinola, Mexico, *Journal Washington Academy of Sciences*, 16:333, June 19, 1926. The length of lint in *Gossypium morrilli* p. 339 should be corrected to seven-eighths of an inch, instead of "eight inches." On the same page change "Kehchi" to Kekchi, and on page 333 "W. W. Morrill" to A. W. Morrill.

In most cases the occurence of large overlapping auricles is confined to the large leaves, but in some forms the medium-sized and small leaves may have the sinus closed. One plant at Cocorit predominated in the development of the auricles, especially in the small leaves, and many cases were noted where the petiole, being short, did not reach beyond the basal expansion of the auricles.

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Nectaries on Pedicels

The involucre of the cotton plant has two sets of nectaries which are considered as extra-floral, a set of three "inner" nectaries alternating with the involucral bracts and a set of three "outer" nectaries opposite the bracts. The inner nectaries are located on the base of the calyx, at the angles between the bracts, while the outer nectaries are located on the receptacle in the sinus of the insertion of the bract, which usually is curved.

The usual form of the external nec-

tary is a rounded depression, but sometimes oval or reniform, and in rare cases divided through the middle.

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In addition to the unusual position of the nectaries of *Gossypium hypadenum*, the structure of the nectaries also is peculiar. Instead of occupying a rounded or transverse depression, the nectar-bearing tissue is found in a narrow groove in the middle of a longitudinal ridge that runs down the pedicel.

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Small Open Involucres

One of the Mexican species was named *Gossypium patens* in allusion to the small open involucres which are a characteristic feature. The involucral bracts not only are small but are widest in the middle and distinctly narrowed at the base where the bracts of most of the species of Gossypium are broadened and deepened below the point of attachment to form the usual basal auricles, which meet at the angles and give the cotton involucre its usual three-cornered form.

The bracts of *Gossypium patens* not only lack auricles, but the lower margins, instead of being opposed to each other are turned back and stand separate, so that there is no approximation to the condition of the closed involucres that have been observed in Kekchi and Rabinal cottons of Guatamala.*

Bractlets Present or Absent

The bractlets are small organs located immediately inside the involucre at the angles or openings between the bracts. They occur frequently on some of the native cottons, on others rarely, and in some no bractlets could be found. The most frequent and regular occurrence of bractlets was in *Gossypium contextum*, but they are usually present in *G. patens* and were noted also in *G. morrilli*.

The relation of the bractlets to the bracts as part of the involucre has not been determined. The bracts undoubtedly correspond to leaves, and many intermediate stages have been found between leaves and bracts, including many cases where the same organ showed leaf characters on one side and bract characters on the other, with the stipules enlarged and the blade element reduced.

From studies of such cases it has appeared that the lateral teeth of the bracts may have been formed by reduplication of the stipules, and on that basis the bractlets may be considered supernumerary stipules, that have failed to unite with the bracts. The irregular occurrence of the bractlets would be associated in this view with the usual irregularity in the numbers of teeth in the bracts.

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tion of the calyx in protecting the bud having been assumed by the involucre. In several species of Gossypium the calyx has been reduced to a shallow rim around the base of the corolla, with the lobes entirely suppressed or indicated by a slightly sinuate margin. Some species have distinctly rounded short lobes, or lobes that are distinctly but broadly angled; also there are species with well-developed calyx lobes, acutely angled; and finally there are lobes with angles produced into sharp tips or with slender subulate "tails." The occurrence of such tails usually is not regular, even in the same calyx. One or two of the lobes may be tailed while the others are not.

All of the new cottons from Mexico have the calyx lobes distinct and sharply angled, and tailed calyx lobes are of frequent occurrence except in *Gossypium dicladum*. In *G. hypadenum* and *G. patens* all of the five lobes of the calyx commonly have tails.

Oil-Glands Absent on Sutural Bands

The carpels that make up the cotton boll in most cases are completely fused together, with no surface indication of the suture or line of union where the carpels are united. But in some cases the suture is indicated by short grooves at the tip of the boll, and sometimes at the base.

Another indication of the sutures is an absence of oil glands from vertical bands on the surface of the boll, in the position of the sutures. A tendency to fewer oil glands over the sutures is often observable in Upland cotton and also in some of the second-generation hybrids of Egyptian and Upland cotton. This character has been observed in some of the variations of the Kekchi cotton of Guatemala, though not as a regular feature, and in the native Moqui or Hopi cotton, cultivated by the Indians of northern Arizona.*

Two of the Mexican cottons show a definite absence of oil glands along the suture or line of division between the carpels. In other respects, the two species are very different. One of them is *Gossypium hypadenum*, the species with the undulate leaf-margins and peculiar nectaries already described. The other species is *Gossypium contextum*, with leaf-forms and nectaries of the usual types.

Lint Attached to Carpel Walls

A remarkable feature of one of the new cottons from Mexico, *Gossypium contextum*, is the occurrence of numerous long fibers attached to the carpel walls, sometimes over most of the surface. In some cases these attached fibers are so numerous and so generally distributed as to appear as a complete lining of the carpels, which remains in place after the seeds have been removed. (See Figure 12).

Fibers have been found previously on the carpel walls of Thurberia, the "wild cotton" of Arizona, and occasionally in Egyptian cotton or in hybrids of Egyptian and Hindi cotton, but in all of the previous cases these carpel hairs were few in number and were confined to the middle of the carpel, close to the fissure.†

In *Gossypium contextum* the inner surface of the mature carpels is very finely and closely wrinkled, and the ends of some of the fibers apparently are caught and held in these wrinkles. In other cases the fibers are held by what may prove to be hardened exudation; thus it is not certain that the attached fibers have actually grown from the walls. Further study will be needed to determine definitely the method of attachment.

*Weevil-Resisting Adaptations of the Cotton Plant, p. 52.
†See Mutative Reversions in Cotton, *Circular* 53, Bureau of Plant Industry, 1910, p. 6.

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